

# **LLNL/DOE Individual Radiation Protection Monitoring kin Rongelap resettlement worker ro ilo kotaan 1999–2002: An Overview**

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## **LLNL/DOE Individual Radiation Protection Monitoring of Rongelap Resettlement Workers during 1999–2002: An Overview**

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**#Rongelap Whole Body Counting Facility  
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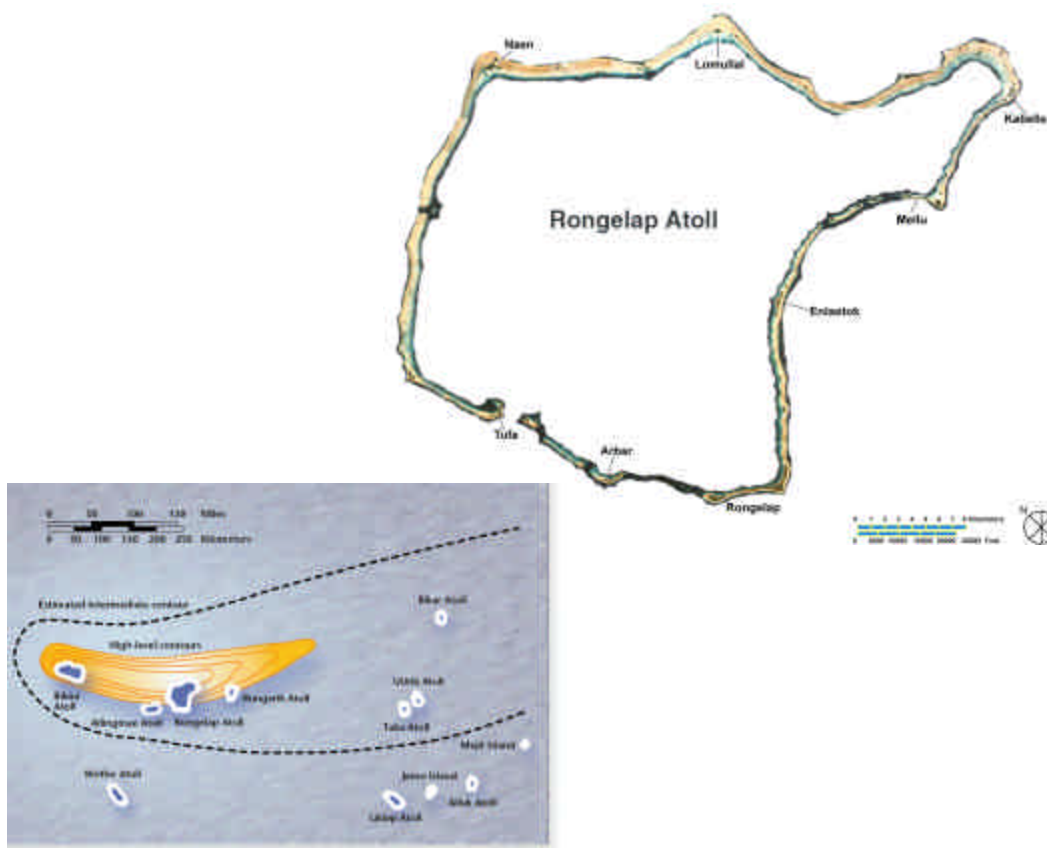
**(for further information, visit <http://en-env.llnl.gov/mi/>)**

**Community Meeting  
November 2002**

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## KOMELELE

Ilo Maaj 1 1954 eo United States ear komman kokmalmel in nuclear bomb ion Bikini Atoll ilo tuionturilik in Marshall Islands im at eo ettino ar “Bravo” eo ear tollok nan ererak in paijin ion enejidik ko ear wor armej ie ilo Rongelap Atoll im aelon ko jet iturear in Bikini. Jonan oran in 64 armej rej jokwe ilo Rongelap rekar jedmatmat nan paijin kein (radioactive fallout), im rekar aikuij bok er nan Kwajalein Atoll nan lolok jikin komadmod ko an takto. Jukjugin pad eo i’Rongelap en rekar ilo 3 iio ko tokalik rekar jokwe ion Ejit Island (Majuro Atoll) mokta jan rool nan lamoren eo aer i’Rongelap ilo Juwun 1957. Ijoke, inebata ko rej jebar jan jorran in ajmour ko jan wot jedmatmat nan paijin kein rekar wotlok ion aelon en rekar iuuni ri aelon en nan bar emakit ilo 1985 eo nan juon jikin jokwe ilo Mejjato Island (Kwajalein Atoll).



## KIOMELMEL KO ILO EBEBEN EO MAN

Jukjuki pad eo an ri Rongelap ien otemjej rekar kwalok juon ikdelel ekajoor nan roollok nan ijo rej watoke bwe ej aer lamoren ilo Rongelap en. Kien eo an U.S. ear bareinwot watoke bwe emman nan jukjuki pad in an ri Rongelap bwe armej rein ren bar rool non lamoren in aer. Rongelap Resettlement Act ej kemlet kon jet jekjek ko nan karool armej in Rongelap Atoll jan wot waween ko rekar ejaak ilo Rongelap ilo ien eo United States ear bok eddo in Trust Territory of the Pacific Islands im uake juon kajjitok jan jukjuki pad eo an Rongelap. Lelkan 1 resettlement ear ijino ilo 1998 eo alkin juon ien jermal in kanuuj karok im arto-artak jermal kein ippan kumi ko retijemlok. Ri tol ro an Rongelap rekar bareinwot komman bwe U.S. Department of Energy eo en ejaake juon karkan rejtake jermal in etale belaak eo ijen nan kamooli elanne kilen karreo ko jermal rej jermal ak jaab, im nan ejaake local resource ko im jela ilo individual radiation protection monitoring. U.S. Department of Energy eo, Rongelap Atoll Local Government eo, im Kien eo an Republic eo an Marshall Islands emoj aer jaini juon Memorandum of Understanding eo ej kolaajraki eon ko rej aeran doon kaki ikkijien rejtake pirokiraam in resettlement in.



Jar in kabellek an rerelokin Rongelap runway im ob (pier).

Ri tol ro an Rongelap elap wonmanlok eo rekar kommane ilo ejaake infrastructure eo aikuiji nan jiban iuun im debij eddok eo an pirokiraam in rool in. Makitkit ko iumin Lelkan 1 rekar kutbuuj ekkal in juon field station non imon ri jermal im ri lolok ro, juon imon jarom, kein ukok den eo im nien den ko nan na mellan aikuij kon jikin denin idaak, ial ko emoj biji im kaetoklok jikin jok an baluun, im juon wob ak atartar an wa ekaal.

## MAKITKIT KO NAN ROOL NAN RONGELAP LELKAN JUON (PHASE ONE)



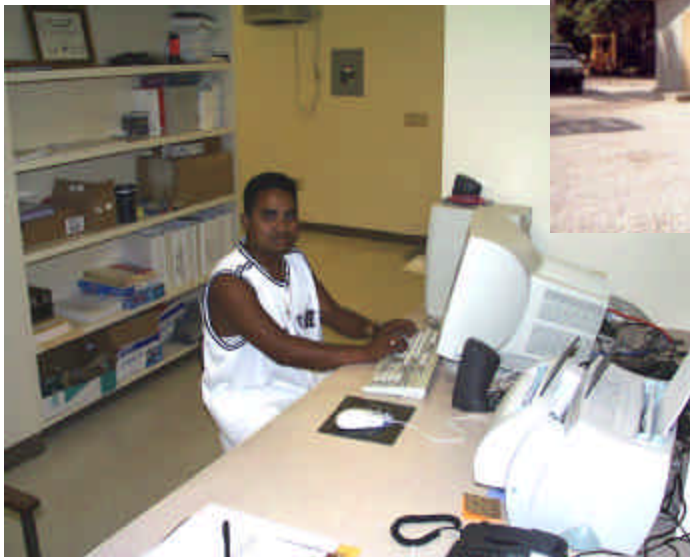
Bar juon ki ilo emakit in karool armej nan Rongelap ekar nan kadiklok jonan radiation eo jedmatmat e ion aelon ilo aer jerbale men eo jej ba “combined cleanup option”.

Komadmod in karreo in ear kanuuj in emman an jermal ilo jermal in idajonjon ko kar kommani ion Bikini en, im kotmene eo in bwe enaaj bareinwot jermal ion Rongelap. Combined option in ej kir nan komakit jidik bwidej im kobaitok wod ko re tibdikdik ilo ibelaakin jikin jokwe eo im ijoko moko imon armej rej pad ie nan kadiklok jedmatmat non radiation, im kojerbale potassium chloride fertilizer eo ibelaakin jikin kallip ko non kadiklol lablok in an mennin eddok ko jeromlonlok Cesium-137. Delon ilo enbwin in Cesium-137 eo ilo ekkan ko kaddoke ion enen ej waween eo eaoroktata non an armej in aelon in jedmatmat nan bween paijin ko rekar wotlok. Kobalok in potassium fertilizer in ej bineje jonan Cesium-137 eo menin eddok ko rej jemore im kadiklok radiation dose eo.



## KOMAKITKIT IN WHOLE BODY COUNTING (WBC) PROGRAM

Jukjuki pad eo i-Rongelap rekar kanuuj ekkol kin ekatak ko an scientist ro kin jekjeki radiation eo ilo aelon eo aer, ak ri tol ro aer rej kee burueer nan jiban bwe en ejjelok jorran nan ejmour im onaake eo an ri jermal ro aer im jukjuki bed eo enaaj roolok. Ri tol ro an ri Rongelap er eo rekar ijino ilo aeran doon kin wonan ko nan kajutake juon jikin kommane Whole Body Counting (WBC) eo ion eonene in Rongelap nan lale bwe aoleb armej ro rej jokwe, mour, im jermal ak lolok aelon en ren kakolkol nan etale jonan gamma-emitting fallout radionuclide ko einwot Cesium-137 ilo tu loa in enbwinier. WBC technician ro rej Ri Majol rekar bok jiljino wiik in kaminene ilo Lawrence Livermore National Laboratory (LLNL), im kio kojerbale er nan komakitkit facility eo nan lon-lok nan 40 awa kajojo wiik. Technician rein jan Rongelap en rej bok eddo in aoleb makitkit ko an WBC facility eo im scientist ro jan LLNL rej boktok jiban ilo technical assistance, kaminene ko relloplok, im lale bwe melele ko boki ren weppen im emman.

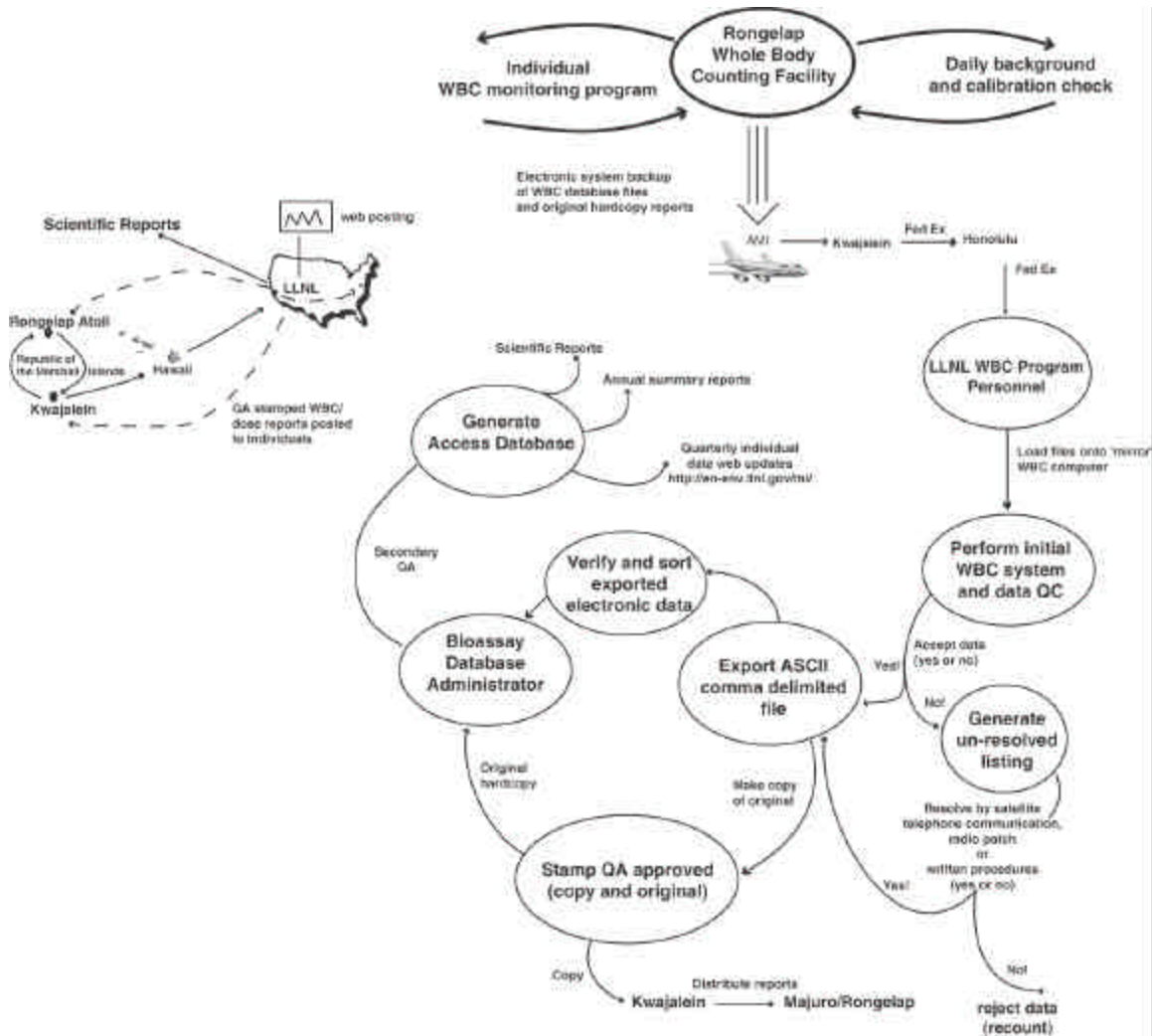


## TA IN WHOLE BODY COUNTING?

WBC system eo ion Rongelap ewor ie elap sodium iodide radiation detector eo ej jone jonan radiation eo ej itok jan enbwinnin armej ro rej jijet iloan juon jikin emoj jeboole. Ekka ba etan system in “Masse-Bolton Chair” design, im maron kojobale nan lo gamma-emitting radionuclide ko ilo enanin aolepen enbwinnin im aoleb organ ko ie. Non etale, kajimwe im kajejjit waween an whole body counter in jermal ej kojobal juon jekjek eo na etan human surrogate source (lale pija ne) im jonan mixed gamma emitting eo ie ewor jela kake im jermaron ba ear ejaak in National Institute of Standards and Technology (NIST). Background im quality control check in bwonbwon ko rej komman aolep raan otemjej nan lale bwe system eo en erra ippan quality requirement ko rekkar. Mokta jen an Scientist ro an LLNL karolok dosimetric information eo bedbed wot ion data ko emoj bwini rej komane juon data quality assurance.



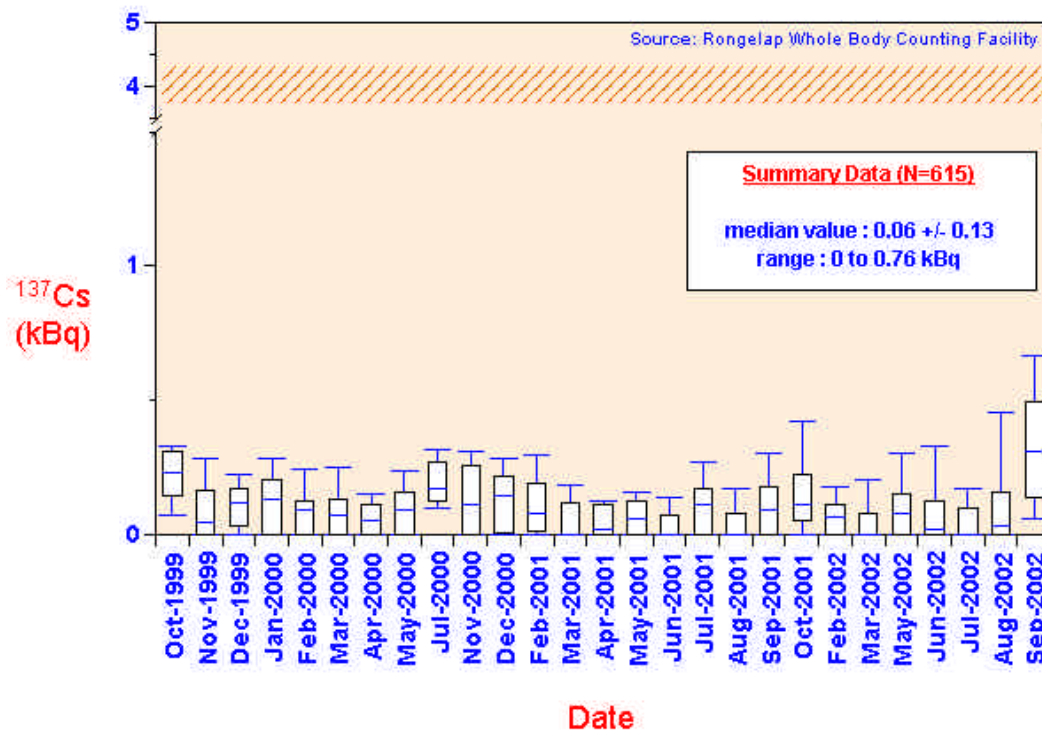
# RONGELAP DATA QUALITY CONTROL



Scientist ro jen Lawrence Livermore National Laboratory kar kōmman jet kain kelajrak ko ñon jibañ kwalok juōn wawen eo eweppen ñon aljek data im tibdriki. Data eo ej rol ñon Lawrence Livermore National Laboratory ijo im enaj kōmman data quality eo etiljek, im melele kein naj kejbaroki ilo juōn electronic database system eo ñon kajededi. Data in im emōj letoletak ej bed wōt ilo jekjek eo etino ñon kejparok etan ro kajojo rej bōk kunair ilo program in. Aolep joñak in data kein im melele ko ibben tok ej driwōjlok ilo report ko ilo juōn iioō im likit ilo world-wide web eo ak <http://en-env.llnl.gov/mi/>.

## TA EO WHOLE BODY COUNTS EJ KWALOKE?

### Results of Whole Body Counting of Rongelap Resettlement Workers (1999-2002)



Joñak in data ko jen whole body count program eo ilo Rongelap Atoll (Octobert 1999- ñon iien in). Line ne e kajimwe ej kwalok kar ran in collection eo(aini).

Joñan level in cesium-137 loe iloan enbwin armij ej kawalok ilo unit in kiloBecquerel (kBq) ko ion vertical axis in. Horizontal axis in ej kwalok ran in bōk sample ko jino jen October 1999. Iloan October 2002, WBC technicians ro rar jerbal ibben eloñ lok jen 600 counts an Rongelap resettlement dri-jerbal ro. Ejañin wōr oktak ko rellap ak spike ko ilo joñan cesium-137 kar lo ilo kōta in. Wawen in kar maroñ jiban kim jolok lemnak ko mokta ke armij ro remaroñ kar bōk spike ko kon joñan ko relōñlok in cesium-137 jen mōña ko buki im kani jen ene ko tueañ, im dose in mottan maroñ kar jab lo ilo program in etale ko manlok. Jouij im melele ilo eñanin aolep keij (joñan 25% in aolep bwinbwin) kein, kemij jab kar maroñ lo cesium-137 ilo dri-jerbal.

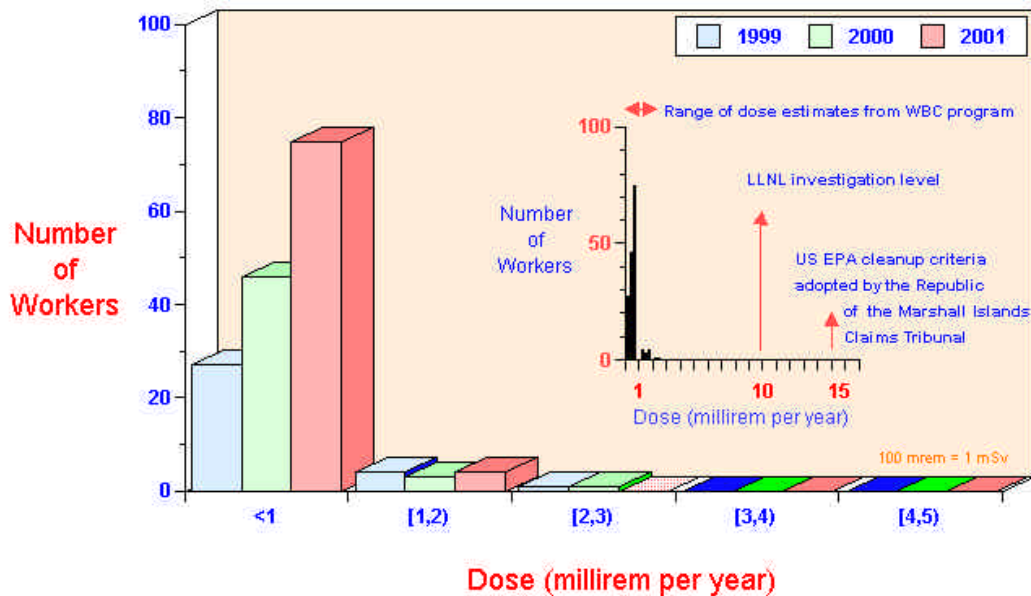


## ANNUAL INTERNAL DOSE

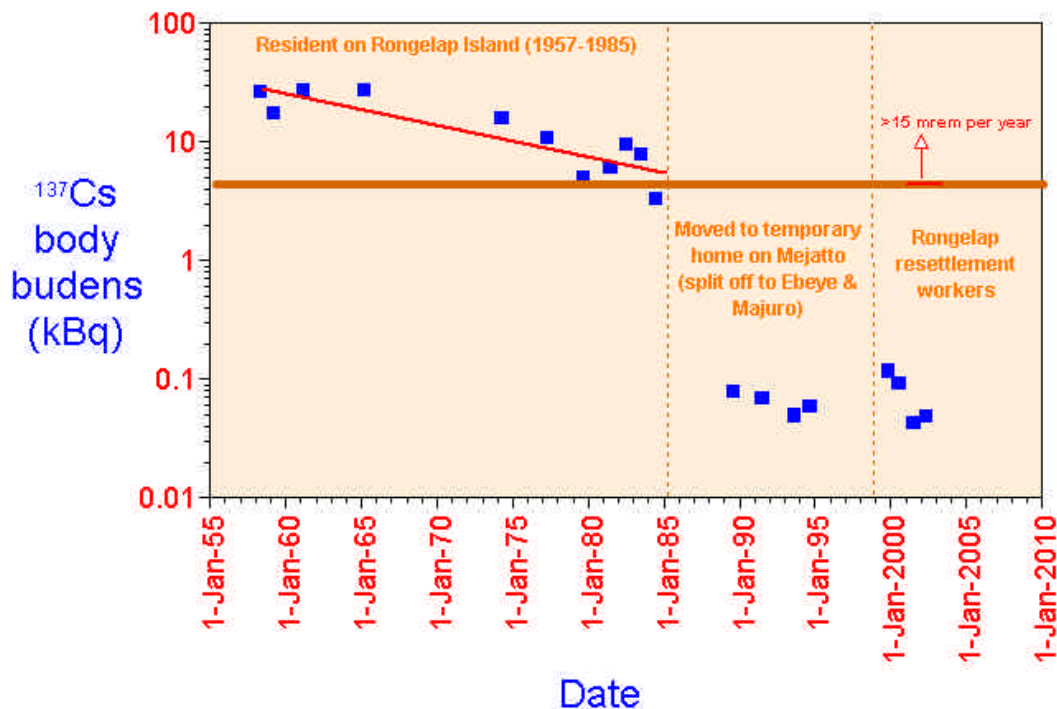
Average dose eo ilo juon ri jermal ro i'Rongelap rar boke ilo iio ko 2 remootlok ediklok jan 1 mrem juon iio ak armej eo ear laptata an jedmatmat ear bok wot 3 mrem ilo juon iio. Antoon in dose kein maron keidi ippan natural background dose kein 140 mrem ilo juon iio ilo Marshall Islands im 300 mrem ilo juon iio ilo United States. Antoon in dose kein rej pedped ion whole body counting in ri jermal ro ion Rongelap im rekanuij le ilalin jonan ko lore ikkijien jermal in karreo eo ej 15 mrem ilo juon iio im Republic eo an Marshall Islands ej kile.

Dose kein antooni ban kwalok kautata eo jemaroñ joñe ak melele kake.

### Annual internal dose to Rongelap resettlement workers from dietary exposure to $^{137}\text{Cs}$ during 1999-2001



## History of uptake of $^{137}\text{Cs}$ in people from Rongelap Atoll including resettlement workers

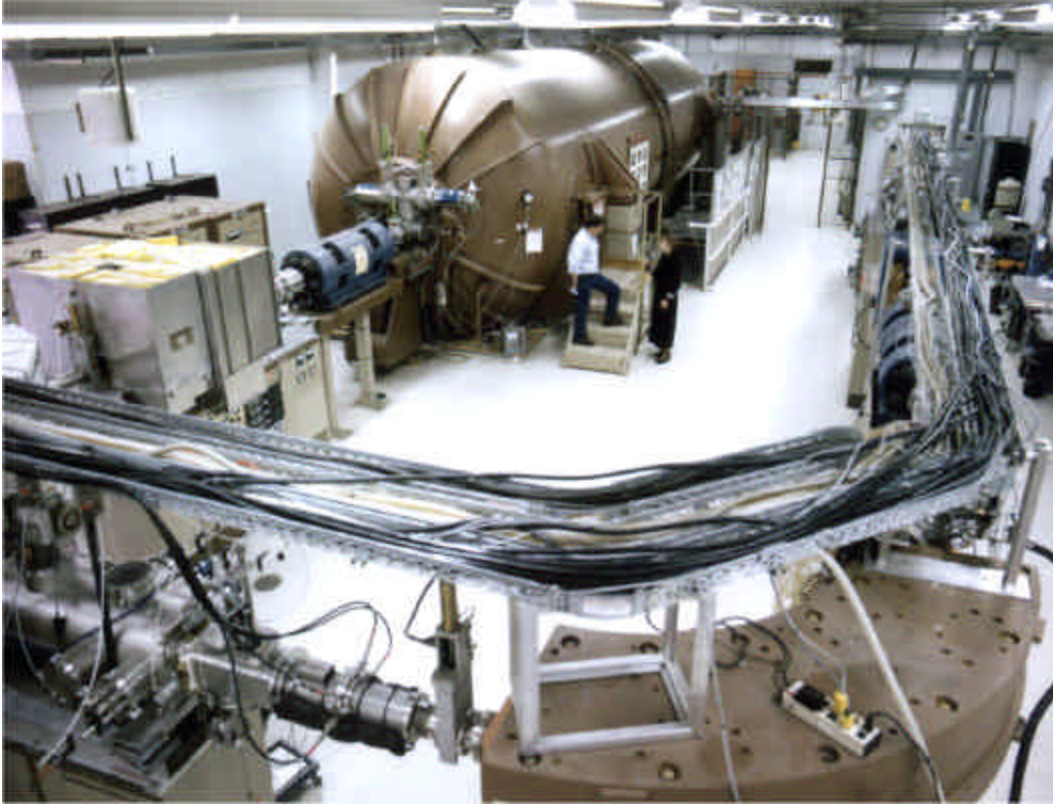


Melele ko aini ilo WBC eo ilo lelkan in imaan ilo bar rool ej barainwot letok juon waween lale eo eman nan jedmatmat ko im jemaron kotmeni nan aer walok iumin jekjek renaj jebar jan kojerbal bwidej ko ilo iio ko tokelik. Ilo wanjonok, dose eo ro raar rool rar boke kotmene eo in bwe renaj le iumin jonok ko kojerbali nan karreo-elaptata alkin bar kokmanmani jikin kallip ko kin potassium. Ri jerbal ro (im ro renaj jokwe ijen ilju im jeklaj) im rekar bok whole body count im ej walok Cesium-137 iumin juon pirokiraam in whole body count eo ej wonmanlok wot emaron kommane juon jemlok ewor pedped in kin waween mona ko an im/ak jekjek in mour eo an pedped wot ion ta eo watoke bwe ej “emman, ak juon kauwotata nan ajmour emaron mour kake”. Whole body counting pirokiraam eo ion Rongelap Island ej litok measurement data im jemlok in ej pedped ion. Melele kein reaikuuj bareinwot aurok nan ri-tol ro an Rongelap ilo aer etale aikuj ko non, im jonan wonen ko remman, ikkijien jerbal in kokmanmanlok ko ak kojerbal kajeikik ko an dolul ko nan lale bwe jerbal kein rej loor jonok in karreo ko kar kwalok ilo ien kab elkin bar rool nan aelon en.

## PLUTONIUM URINALYSIS MONITORING

Plutonium ej juōn radioactive element eo elap tokjen im ej rōlok jen drebolok in nuclear (bomb) ko. Plutonium ej kōtlok ilo aer makitkit wōt jidrik jet men drikdrik ko im rekajur na etair alpha particles (ak alpha rays). Alpha ray ko rej makitkit jet wōt inij ilo mejatoto im maroñ kabwijraki kin juōn pepa ak kil eo tulik emej. Jorren ko im maroñ walok ñon ejmour jen plutonium ej itok jen an tuloa jermatmat kin plutonium itok wōt jen emenono ik bwinal ko re-paijin ak jen bok/bwidej ko re-paijin ilo aer dreloñ enbwin. Bioassay sample ko kar aljeki ilo an erreō jikin jēbal naj jilkinlok ñon Lawrence Livermore National Laboratory ñon kamodmōdi. Juōn kain system in kabbok eo im etijemlok ñon joñjoñ plutonium dredrelok kōmmāne ñon wōt Marshall Islands Urinalysis program eo.

## PLUTONIUM URINALYSIS MONITORING, CONTINUED

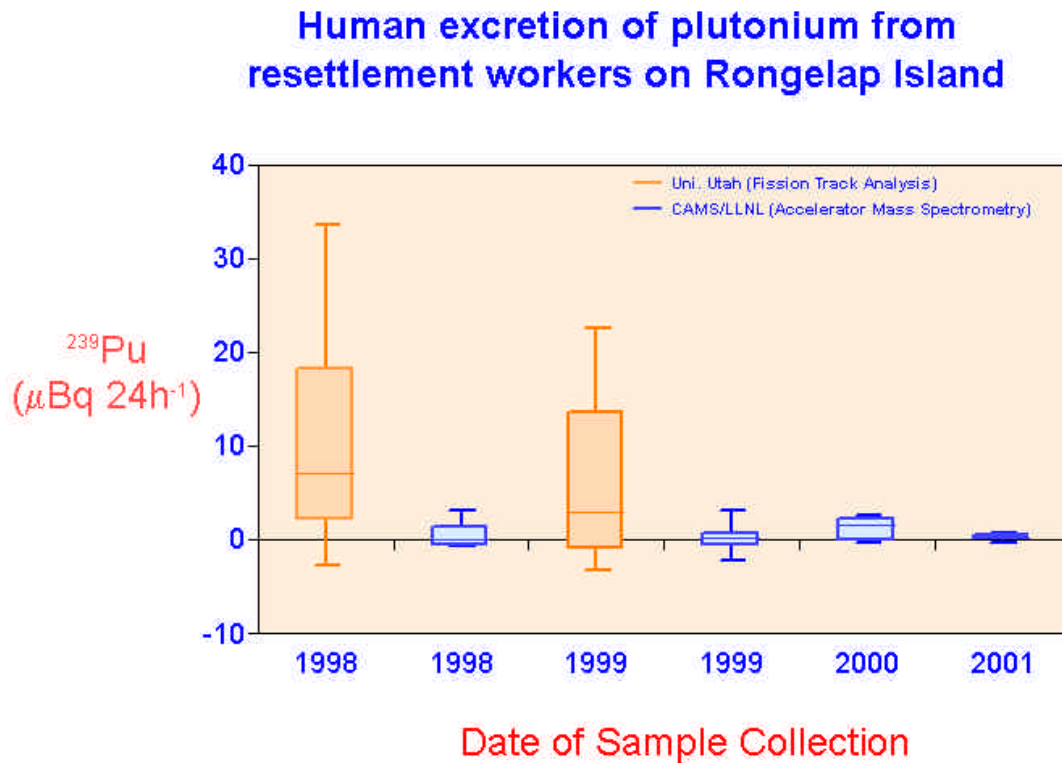


Center eo ñon Accelerator Mass Spectrometry (CAMS) ilo Lawrence Livermore Laboratory eo ej juōn jikin eo elukkun bolel ñon kwalok kabel ko ñon maroñ lo jōñan level ko rettā non joñe plutonium ko ilo bioassay samples ko. Accelerator based measurement technology in elukkun bolel ilo an maroñ joñ e doses ko im dredrik lok jen 0.02 mrem juon iiō. Ilo joñan level in im ej kwalok, jemaroñ joñe jermatmat ko ñon plutonium im ej 7000 alen driklok jen joñan eo armij ejjab maroñ bōbrae, jen aer bōk jermatmat jen radiation ko rejjab kauatata ilo belak.

Technology in ebolel ej jerbal ilo Livermore ñon jepake Rongelap urinalysis program eo im mōj an lukkun le jen aolep requirement ko ñon occupational monitoring programs ko ilo United States.



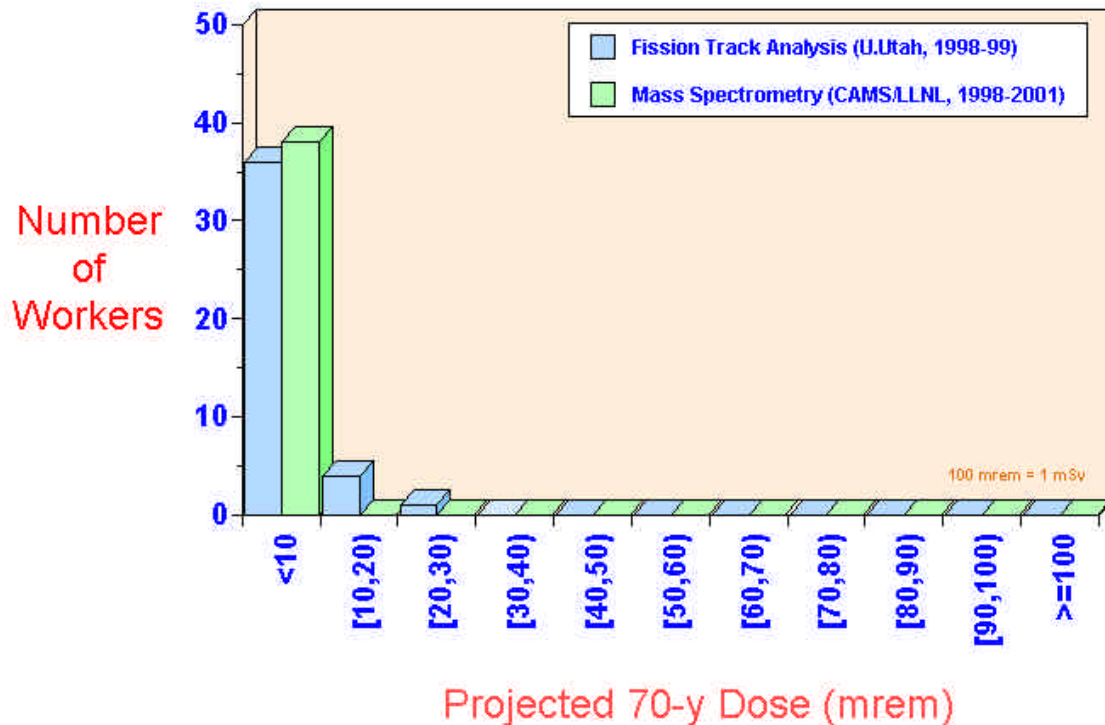
## TA JEMLOK KO PLUTONIUM URINALYSIS EO EJ KWALOK?



Joñan urinary excretion in plutonium jen ro jokwe ilo Rongelap resettlement dri-jerbal ro. Vertical axis eo ej walok measurement data ilo kajojo microBecquerel ( $\mu\text{Bq}$ ) juōn ran. Horinzontal axis eo ej kwalok ran in sampling.

# REMANLOK 70-IIō IN DOSE EO ñON RO REJ JOKWE ILO ENEWETAK JEN AN WOTLOKTOK PLUTONIUM ITULOA.

Projected 70-y dose to Rongelap resettlement workers from internally deposited plutonium

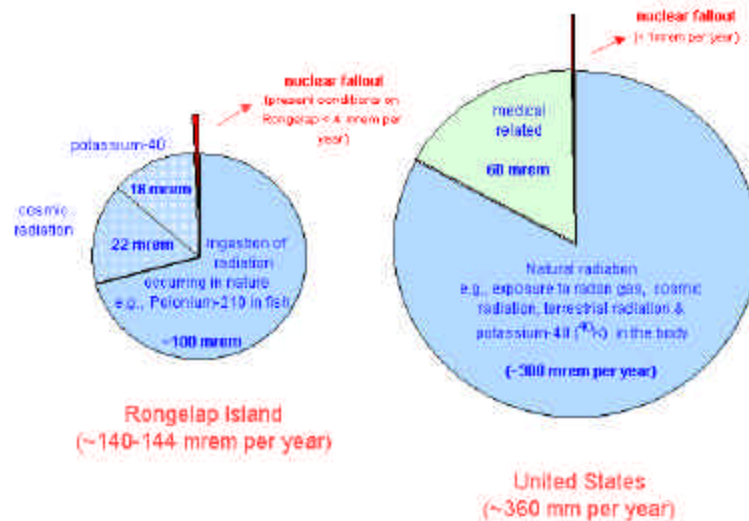


Joñan plutonium eo kar lo ilo bioassay sample ko buki jen kebak 100 armij ro kajojo ilo 1999-2002 kar wōtlok ak bed iumin level eo eaboñ in lo ñon joñak ko. Ilo jekjek in, jeban aikuuj kur ñon report e juōn dose; bōtap, jenaj antoone lok dose eo jen plutonij jiro. Ñon likio in, dose kein wanjoñaki emōj kadreloni ilo report ko am. Lifetime dose eo remañlok kake jen jermatmat ñ on plutonium ñon kajojo ro kar test e er ion Rongelap ej bed iumin 10 mrem ion (ilo?) 70 iioo.

Dose kein emoj antooni ban joñi ak kwalok men ko kautata ñon ejmōur.

# KEIDI RADIATION DOSE KO ILO MARSHALL ISLANDS IM UNITED STATES

## Exposure to natural and man-made sources of radiation



Dose in armij buki jen an dreloñ cesium-137 ilo enbwin jen mōña ko kadreki ijokein aikuij likit ilo juōn wawen eo alikar. Ñon waan joñak, potassium ej juōn men eo aikuiji ñon mour, ak ebar walok ke eor radioactive ie. Potassium-40 eo im ej make walok im ebed ilo enbwin ej letok joñan in 14 mrem ñon joñan dose eo jej bōk ilo juōn iiō ejja ilo wawen eo wōt ikijien cesium-137. Juōn medical X-ray eo im ekkā an aolep bōke enaj kwalok juōn dose in joñane 6 mrem.

Joñan aolepen dose eo itok wōt jen ibelakid ilo Marshall Island ej 140 mrem ilo juōn iiō im joñan in bōke ej itok wōt jen an lap ad mōña eek ko rekel im ear wōr wōt polonium-210 ie. Armij in United States elap lok natural radiation dose eo rej bōke kin joñan in 300 mrem ilo juōn iiō. Joñan eo elikio im ekautata ñon ejmour jen jermatmat in radiation enaj walok jen kōbaik ko itok wōt jen belakir (natural) im dose ko kōmman jen armij. Joñan dose eo ituloa emōj antoone jen ro rar bwinbwin, im ej itok jen cesium-137 eo im emōj joñe ilo enbwinin armij in Rongelap, ej drik lok jen 1% in aolepen natural background dose eo aer.

Dose eo ituloa jen cesium-137 ej bareinwot weippen im bed wōt ilalin joñan eo emōj kōtmene ikijien wawen karreo ko im ej 15 mrem ilo juōn iiō im Republic eo an Marshall Island ear bōk bwe en mwein. Agency ko jen belak in lal in kar kile juōn wawen eo ejjab meralok kon joñanin in 100 mrem tuloñin background eo ñon kejbarok ro uuan lobwilej.

## JEMLOK

WBC data ko boki ion ene in Rongelap ilo iio ko 2 rej jemloklok rej kalikkar ke ri jermal ro ijen rekar bok dose in radiation eo ekanuj dik jan Cesium-137 eo rekar boke ilo mona ko rej kani. Data kein rej bareinwot kwalok bwe kauwotata ko nan ajmour im rej ekkejeltok rekar bareinwot etta. Men in ej bareinwot mool ne ekonono kon high-end dose ko nan ri jermal ro. Pedped wot ion iminene in mona ko im jekjekin mour ko an ri jermal ro, im melele ko (data) aini jan jermal in etale belaak eo im whole body counting pirokiraam eo, einwot enaaj pidodo an pirokiraam in rool nan Rongelap naaj tobraki jonak in 15 mrem ilo juon iio im Republic eo an Marshall Islands ear bok bwe en mweien ilo kakien. Ilo ejja ien in wot, ri tol ro an Rongelap emoj aer kar kwalok ijo konaer im kajutak WBC facility eo ion aelon en nan na mellan jermal in etali jermal in jonjon kein.

WBC system eo enaaj boktok nan armej in Rongelap juon waween kojbarok ikkijien ajmour eo aer rejanin kar loe mae ien eo enaaj alikkar ke level in radiation eo i'aelon en ebed ilo jonan ko im renaaj komman bwe jermal in etale kein ren bwojrak. Aorok en an jermal in etale in ej pedped wot ion unin tol in ke WBC data ko rej na mellan debio in jonjon in jedmatmat otemjeje ilo armej ro ijen. Melele ko kin an kajojo armej jedmatmat im kauwotata ko nan ajmour remaron atooni jan jonjon ko kommani ippaer im jab atartar ion elmakwot ko rej pedped ion waween ko re oktak jen don non bok jedmatmat. Ro rej jokwe ijen im rej bok juon whole body count im ej kwalok ke ewor Cesium-137 remaron kio kommane juon jemlok kon imenene in mona ko aer im/ak waween aer mour pedped ion ta eo rej lomnak ke ejjab kauwotata ak jonan eo kotmene ke emman nan ejmour. Kien eo an Marshall Islands ekar bok bwe en mweien juon clean up dose in 15 mrem kajojo iio ainwot juon jonan risk eo ej kotmene ke emman ñ im ilo an jukjukin in pad eo rool nan aelon eo aer lamoren, kajojo armej remaron bok juon bablal ke kauwotata ko ikkijien ajmour im rej jebar jan radiation rej ped wot ilo ak ilal in jonan ko rekkar im bwe remaron in monono ilo emmanlok ko ilo juon jekjek in mour eo emman.





## GLOSSARY OF TERMS

### Becquerel (Bq)

Juōn becquerel (tukadu I ej Bq) ej International System (SI) unit eo ñon makitkit ko an juōn men eo ej radioactive. Juōn Bq in men ko rej radioactive ej joñan men eo im juōn atom ej jenij ak bōk juōn decay aolep second.

### Calibration

Juōn Wawen kajimwe uuak eo an juōn kein jerbal ñon kwalok reading ko rejijet.

### Critical Level

Joñan oran numba in bwinbwin ko ilo ak iloñin wawen eo juōn decision ej kōmman ke juōn radioactive material ej lukkun alikar ke ebed.

### Dose Equivalent

Dose equivalent ej dose eo bōke ilo ad jela kin biological effectiveness in radiation ñon an maroñ kwalok jorren.

### High End Health Risk

Ej kwalok joñan eo elap juōn armij naj bōk jermatmat ilo juōn population.

### Internal Dose or Exposure

Mōttan dose eo einwot joñan eo bōk jen radiation source ko ilon enbwin.

### Individual

Kajojo armij.

### Isotope

Juōn atom jen ejjā element eo wōt im eōr oktak drik ko ilo atomic mass eo ie. Jej kile isotopes ko roktak ilo kobaik juōn nōmba eo ej kwalok drebio in isotope eo ñon etan element eo. Juōn example ej cesium-137 eo im ekkā ilo tukaru,  $^{137}\text{Cs}$ , ijo ej kwalok chemical symbol eo ñon cesium ej Cs.

### Quality Assurance

Bunten ne ko buki ñon drebij juōn wawen joñjon eo ñon kalikar rej bed wōt ilo jekjek eo emoj kwalok.

### Radiation Dose

Radiation Dose ej juōn generic tōrm kejerbale ñon antoone radiation eo maroñ kwalok jorren ko ñ on ejmour im ej ekkā an walok ilo unit in mrem ilo juōn iioō.

### Radioactivity

Juōn natural ak spontaneous process eo ej kwalok atom ko rejjab kon ilo juōn element ilo aer kadruwojlok energy im/ak mendrikdrik ko, im jenij (ak makunlok) ñon juōn element eo eoktak ak isotope ko roktak ilo ejjā element in wōt.

# Appendix 1


## Individual Annual Dose Report

Aoleb volunteer ro rar bok juon aer individual (kajojo) annual (juon yio) dose report ilo yio ko kajojo im rej bed ilo program in whole body counting ak plutonium urinalysis.

Sample in dose report eo ej walok itu-lal.

Report in ej kwalok kin annual (yio) dose eo kajojo rekar bok ilo yio en. Dose in emaron lale ta oktak ibben juon natural background dose kin 140 mrem ilo Marshall Islands (ak rebed ibben armij ro ilo Marshall Islands). Report in ej bareinwot koba juon copy kin aoleben verified measurement data eo me ej jermal non jone jonan dose eo.

Sample copy only

	<b>Lawrence Livermore National Laboratory</b> HEALTH & ECOLOGICAL ASSESSMENT DIVISION
October 21, 2001 ID# «PersonID»Eo Am Maimaka:	
NON:	«FirstName» «LastName»
IEN:	Dr. Terry Hamilton Marshall Islands Program Leader Lawrence Livermore National Laboratory
UN EO:	Report in jermal in Etale Jonan Baijin.
Dear eo ej Bok Konam:	
Inceoto in liket ijin juon copy in report in jermal in etale jonan dose in baijin eo am makumake ilo tore eo maantak nem 31 December 2001 (lale melale ko ijin).	
Departmeni eo an Energy kobalok ibben rijerbal (technicians) in aoleb kaiti ro rit komon jermal in etale jonan dose eo (ne ewor) ilo enbwinom ilo as kijaertal krenadmod in Whole Body Counting (WBC) non lale etale ewor etale 137 eae dekon ilon enbwinom. Jeonk kein (data) kar tohzer kar kobaiki iten dion in ukoel in jaos wof dose ilon enbwin non juon yio einwor an walok ijin ilal. Kim kar bareinwot etale dion in kabojoik (mat) in rijerbal ro non komon jermal in etale etale ewor an eae ejadnatmat non plutonium (ne ewor) in maitoto eo kwij ematocoki. Etale walok jonan deetas kein jone inem dose eo ilon rebwin non juon yio einwor an walok ej koba in dose ko an in kar antonilok.	
<b>JONAN DOSE EO ERED ILO ENBWINOM ILO YIO IN 2001, KAR ANTONILOK BWE EJ</b> «Total_Dose_2001» millirem (mrem).	
Jinas in etale as dikkok, jen jonan dose eo etaleas ri Amerika kan rej tote eo in ej 100 mrem juon yio non aolep armij, in ediklok jen 15 mrem jace yio eo in Republic eo an Marshall Islands eae kile.	
Kin mema, ekkar non jekjek in wewer an bed in mairijerbal ej alikar bwe etale kein boame baijin in rajinien ko liwej non yik.	
Kommol kin an bok konam.	
An Equal Opportunity Employer • University of California • P.O. Box 808 Livermore, CA 94551-0808 • Telephone (925) 422-1100 • Fax (925) 386-6229 TDD/1111/1/1/1	

### Individual Radiation Monitoring Report

Personal ID	Last Name	First Name	Address
0000000	Doe	John	Lawrence Livermore National Laboratory P.O. Box 808 Livermore CA 94539 United States of America

### Internal Dose Report

Year	Cesium-137		Plutonium-239		Plutonium-240	
	Annual Dose	CEDE*	Annual Dose	CEDE*	Annual Dose	CEDE*
	mrem	mrem	mrem	mrem	mrem	mrem
2001	15.0	21.0	0.00	0.0	0.00	0.0

\*CEDE=Committed Effective Dose Equivalent over 70 years.

The amount of radiation a person receives is called the "effective dose equivalent" and is measured in thousandths of a rem (called the millirem) and is abbreviated or shortened to mrem. Your internal dose from ingestion of cesium-137 and inhalation of plutonium-239 has been converted into a single internal annual dose and a CEDE as shown above. This compares with an estimated Marshall Islands background dose of 140 mrem/year. The international scientific community has adopted the use of a different term for millirem called the millisievert (mSv). A millirem is the same as one-hundredth of a mSv.

### Cesium-137 Internal Monitoring Data

#### Whole Body Counting (WBC)

Date of Count	Nuclide	Unit	Activity	Uncertainty Range	
				Maximum	Minimum
5/21/01	Cesium-137	kBq	4.20	4.62	3.78
6/28/01	Cesium-137	kBq	4.20	4.62	3.78
9/10/01	Cesium-137	kBq	4.20	4.62	3.78
10/12/01	Cesium-137	kBq	4.20	4.62	3.78
12/12/01	Cesium-137	kBq	4.20	4.62	3.78

### Plutonium Internal Monitoring Data

#### Plutonium Urinalysis (Pu in urine)

Date of Collection	Nuclide	Unit	Activity	Uncertainty Range	
				Maximum	Minimum
8/1/01	Plutonium-239	nBq/24 h void	0.0	0.0	0.0
8/1/01	Plutonium-240	nBq/24 h void	0.0	0.0	0.0

Plutonium analyses were performed by the Center for Mass Spectrometry at the Lawrence Livermore National Laboratory using the new state-of-the-art measurement technology Accelerator Mass Spectrometry (AMS). Accelerator mass spectrometry is about 100 times more sensitive compared with classical bioassay monitoring techniques. The results show that levels of plutonium in your urine are within the normal worldwide background range.

# **LLNL/DOE Individual Radiation Protection Monitoring of Rongelap Resettlement Workers during 1999–2002: An Overview**

**Terry Hamilton  
and  
Ericson Arelong#  
Simon Langinbelik#**



**Lawrence Livermore National Laboratory  
P.O. Box 808  
Livermore, CA 94550  
U.S.A.  
(e-mail: [hamilton18@llnl.gov](mailto:hamilton18@llnl.gov))**

**#Rongelap Whole Body Counting Facility  
Rongelap Atoll Local Government  
P.O. Box 238  
Majuro, MH 96960**



**(for further information, visit <http://en-env.llnl.gov/mi/>)**

## **Community Meeting November 2002**

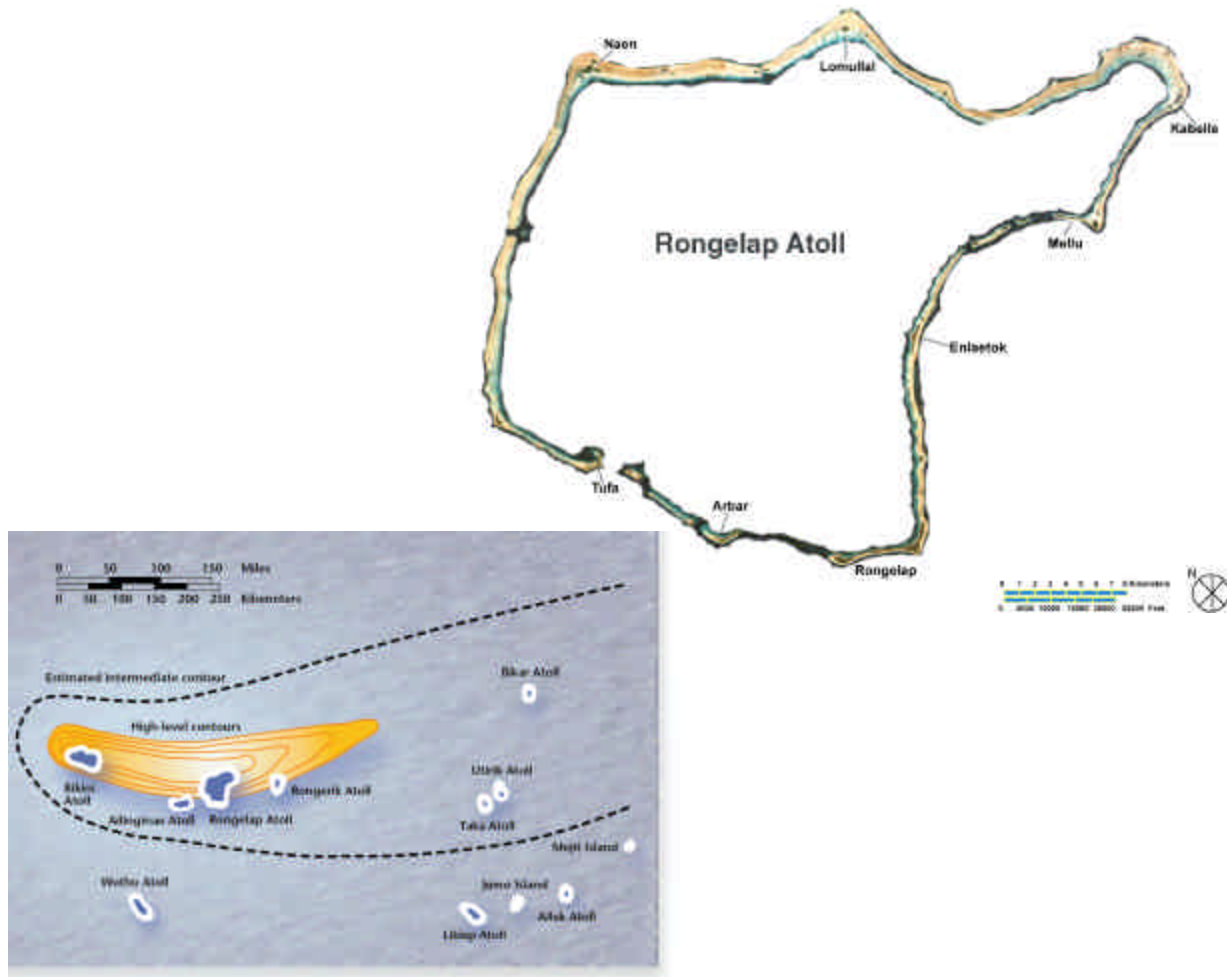
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This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-750-Eng-48.



## BACKGROUND

On March 1 1954 the United States conducted a nuclear test on Bikini Atoll in the northern Marshall Islands code named 'Bravo' that led to widespread fallout contamination over inhabited islands of Rongelap Atoll and other atolls to the east of Bikini. A total of 64 people living on Rongelap received significant exposure to radioactive fallout, and had to be evacuated to Kwajalein Atoll for medical treatment. The Rongelap community spent the next 3 years living on Ejit Island (Majuro Atoll) before returning home to Rongelap in June 1957. However, growing concerns about the possible health effects of exposure to residual fallout contamination on the island prompted residents to relocate again in 1985 to a new temporary home on Mejatto Island (Kwajalein Atoll).



## POST TESTING ERA

The Rongelap community have always expressed a strong desire to return to their ancestral homeland on Rongelap. The US Government also considered that resettlement was in the best interests of the community. The Rongelap Resettlement Act of 1999 (H.R.2970) prescribes certain terms for the resettlement of the people of Rongelap Atoll due to conditions created at Rongelap during United States administration of the Trust Territory of the Pacific Islands and responds to a petition by the Rongelap Community. Through H.R.2970, the US Congress approved and continued a 1996 resettlement agreement between the United States and the Rongelap Atoll Local Government, and extended distribution authority for ten years to advance resettlement. As a part of the 1996 resettlement agreement, Phase I resettlement began in 1998 after a period of very careful planning and consultation with expert groups. Rongelap leaders also engaged the US Department of Energy in developing a resettlement support plan to provide environmental monitoring to verify the effectiveness of cleanup methods, and develop local resources and expertise in individual radiation protection monitoring. The US Department of Energy, the Rongelap Atoll Local Government, and the Republic of the Marshall Islands have since signed a Memorandum of Understanding outlining shared provisions in support of the resettlement program.



Opening ceremony marking completion of the Rongelap runway and pier.

Rongelap leaders have made significant progress in developing the necessary infrastructure to help foster and sustain a prosperous resettlement program. Phase I resettlement activities have included the construction of a modern field station to accommodate workers and visitors, a power plant, reverse osmosis units and holding tanks to provide a clean source of fresh water, paved roads and extended runway, and a new dock.

## RONGELAP PHASE ONE RESETTLEMENT ACTIVITIES



Another key resettlement initiative was to reduce the level of radiation exposure on the island by employing a "combined cleanup option".

This remediation technique has been very successful in large scale experiments conducted on Bikini Island, and is expected to be equally effective on Rongelap. The combined option calls for limited soil removal and addition of crushed coral fill in and around the village and housing areas to reduce external radiation exposure, and application of potassium chloride fertilizer around the agricultural areas to reduce the uptake of Cesium-137. The ingestion of Cesium-137 contained in locally grown food represents the most important pathway for exposure of island residents to residual fallout contamination. The addition of potassium fertilizer competitively blocks the amount of Cesium-137 taken up into the locally grown foods and reduces the radiation dose.

## **IMPLEMENTATION OF THE WHOLE BODY COUNTING (WBC) PROGRAM ON RONGELAP ISLAND**

The Rongelap community has been highly skeptical of scientific studies on the radiological conditions of their atoll, but their leaders are committed to helping ensure the health and safety of their workers and resettled community. Rongelap leaders took the initiative to share in the costs of establishing a Whole Body Counting (WBC) facility on Rongelap Island to enable all individuals – living, working, or visiting the island to be monitored for internally deposited gamma-emitting fallout radionuclides such as Cesium-137. Local Marshallese WBC technicians received six weeks of intensive training at the Lawrence Livermore National Laboratory, and are employed to run the facility for up to 40 hours per week. The local technicians are responsible for all daily operations in the WBC facility while scientists from the Lawrence Livermore National Laboratory (LLNL) provide on-going technical assistance, advanced training, and data quality assurance.



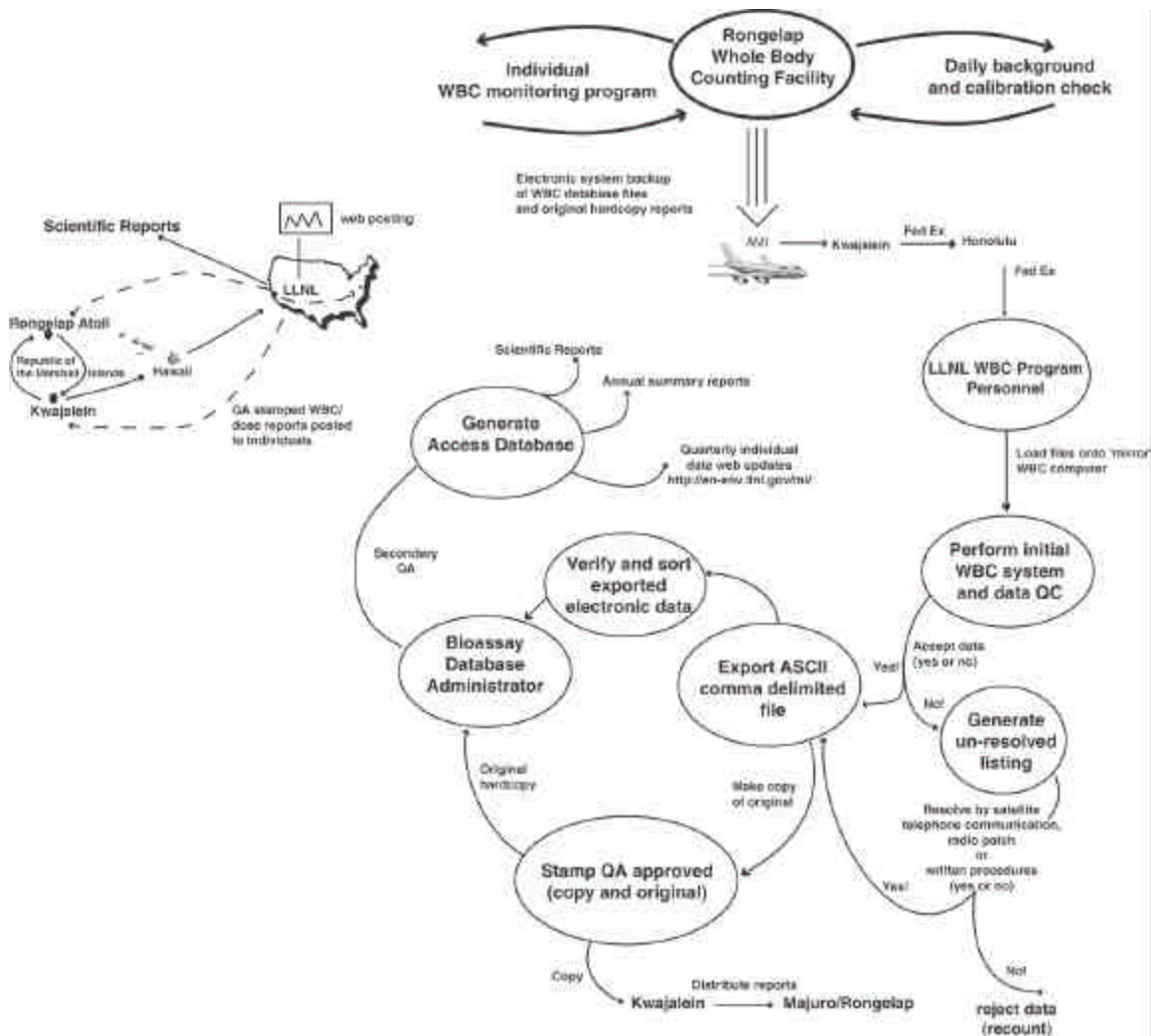


## WHAT IS WHOLE BODY COUNTING?

The WBC system on Rongelap contains a large volume sodium iodide radiation detector that measures radiation coming from the body of people sitting inside a shielded enclosure. The system is typically referred to as the "Masse-Bolton Chair" design, and can be used to detect gamma-emitting radionuclides in most of the body and all of the internal organs. The whole body counter is calibrated using a human surrogate calibration source (refer to photograph) filled with a known amount of a mixed gamma-emitting standard traceable to the National Institute of Standards and Technology (NIST). Background and other quality control check counts are performed on a daily basis to ensure that the system conforms with applicable quality requirements. Scientists from the Lawrence Livermore National Laboratory, before release of dosimetric information based on the measurement data, perform a more detailed data quality assurance appraisal.



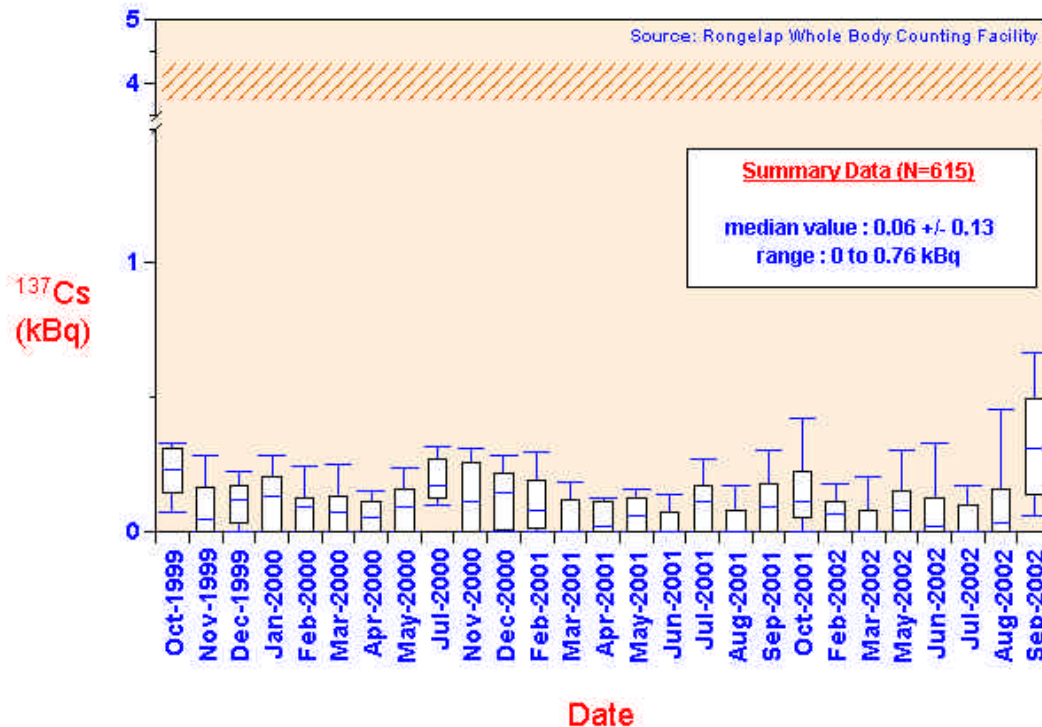
# RONGELAP DATA QUALITY CONTROL



Scientists from the Lawrence Livermore National Laboratory have designed special procedures to help ensure a high standard of data collection and analysis. The data is returned to the Lawrence Livermore National Laboratory where a thorough data quality review is performed and the information saved in an electronic database system for wider distribution. The distributed data is all deidentified to protect the names of individuals contributing to the program. All the measurement data and related information are released in annual reports, and posted on the world wide web at <http://en-env.llnl.gov/mi/>.

# WHAT DO THE WHOLE BODY COUNTS SHOW?

## Results of Whole Body Counting of Rongelap Resettlement Workers (1999-2002)



Measurement data from the whole body counting program on Rongelap Atoll (October 1999-present).

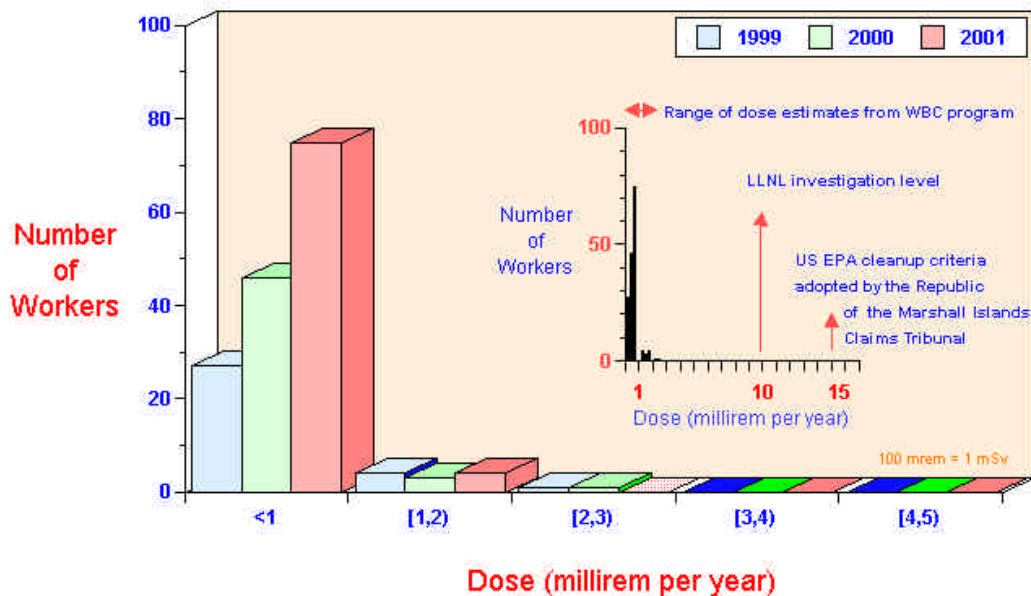
The level of cesium-137 found inside the body of people is expressed in units of kiloBecquerel (kBq) shown here on the vertical axis. The horizontal axis shows the date of collection beginning in October 1999. Through October 2002 whole body counting technicians have performed over 600 counts on Rongelap resettlement workers. There have been no systematic changes or spikes in the amount of cesium-137 detected over this period. This helps us rule out earlier concerns that people may have been receiving incremental spikes in cesium-137 from eating foods collected from the northern islands, and that the associated dose was missed during earlier monitoring programs. Please note that in many cases (about 25% of all counts) we were not able to detect any cesium-137 in workers.

## ANNUAL INTERNAL DOSE

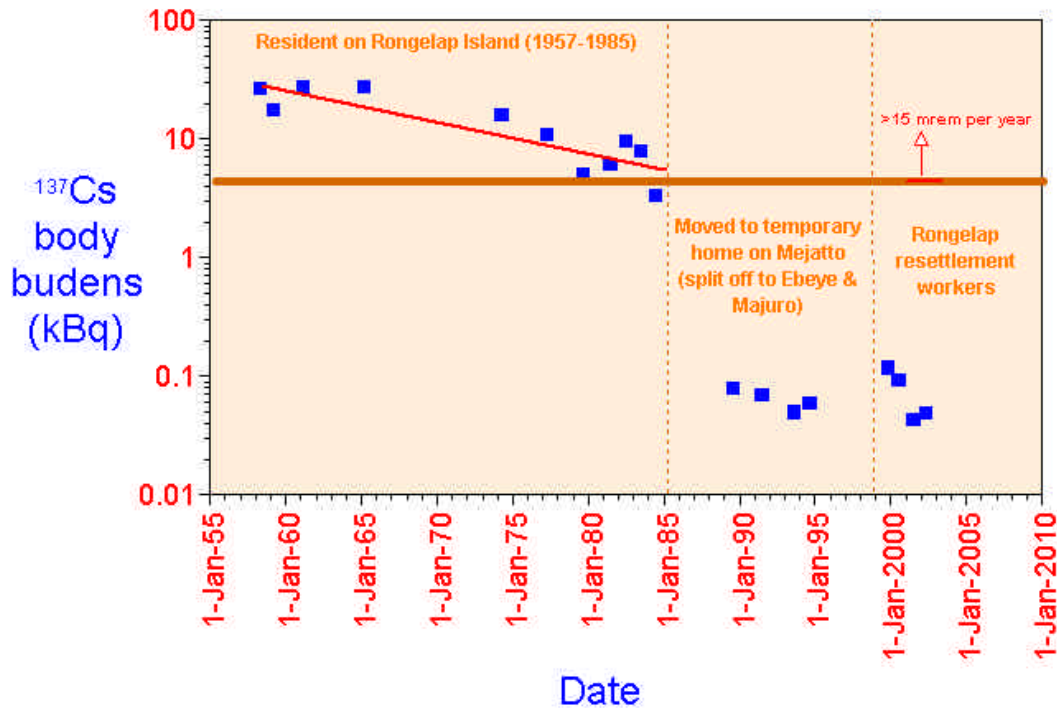
The average annual dose received by Rongelap resettlement workers over the past 2 years is less than 1 mrem per year while the maximally exposed individual is only 3 mrem per year. These dose estimates can be compared with a natural background dose of 140 mrem per year in the Marshall Islands, and 300 mrem per year in the United States. Furthermore, dose estimates based on whole body counting of Rongelap workers are well below the cleanup standard of 15 mrem per year, established by the Republic of the Marshall Islands.

The estimated doses pose no measurable or discernable health risk.

### Annual internal dose to Rongelap resettlement workers from dietary exposure to $^{137}\text{Cs}$ during 1999-2001



## History of uptake of $^{137}\text{Cs}$ in people from Rongelap Atoll including resettlement workers



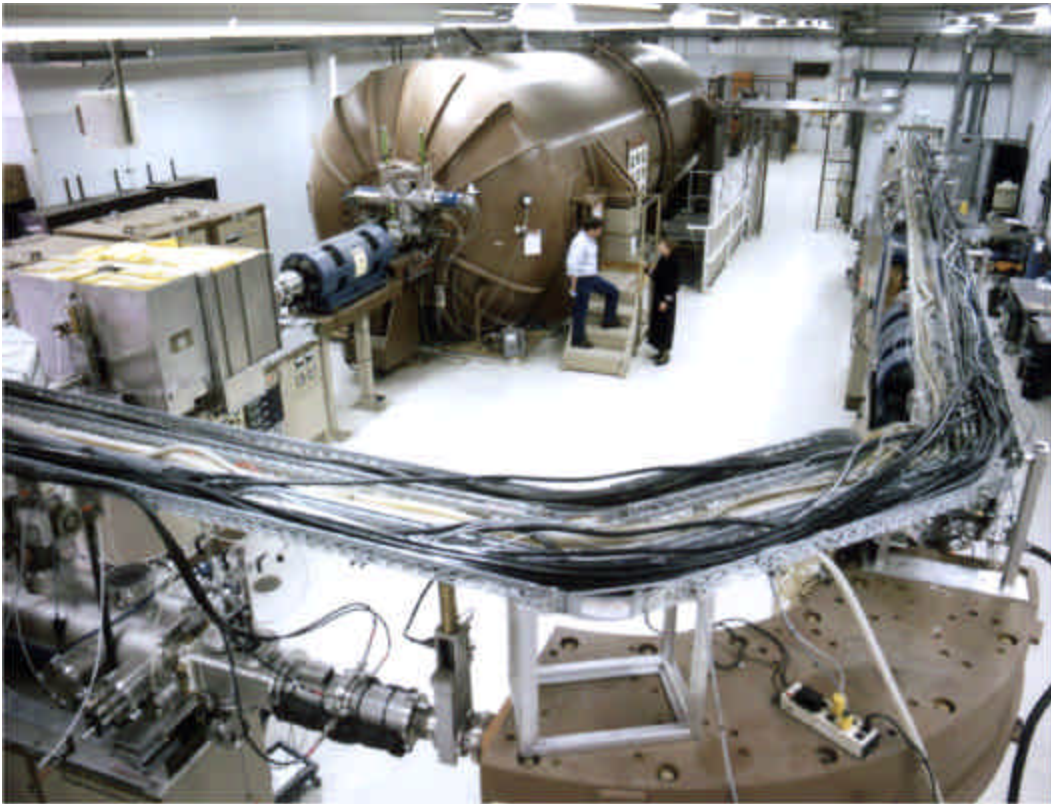
The WBC data collected during this initial phase of resettlement also provides a good insight into exposures that could reasonably be expected to occur under future land use conditions. By analogy, the doses received by the resettled population are expected to be below the cleanup standard – especially after remediation of the agricultural areas with potassium. Workers (and future residents) who receive a whole body count that show the presence of Cesium-137 under a continued whole body count program will be able to make an informed decision about their eating habits and/or life style based on what is considered a ‘safe’ or acceptable health risk. The whole body counting program on Rongelap Island provides the measurement data on which to base this decision. This information should also be extremely valuable to the Rongelap leadership in determining the need for, and relative cost-benefits, of further remediation or use of institutional controls to ensure compliance with recommended cleanup standards during and after resettlement.



## **PLUTONIUM URINALYSIS MONITORING**

Plutonium is an important radioactive element released in nuclear explosions. Plutonium emits slow moving, heavy charged particles called alpha particles (or alpha rays). Alpha rays travel only a few inches in air and can be stopped by a piece of paper or the outside layer of dead skin. The potential health effects from plutonium come from internal exposure to plutonium resulting from the inhalation of contaminated dust in the air that people breathe or from ingestion of contaminated soil or food. Bioassay samples collected under clean environmental conditions are shipped to the Lawrence Livermore National Laboratory for analysis. A state-of-the-art detection system for measurement of plutonium was developed especially for the Marshall Islands urinalysis program.

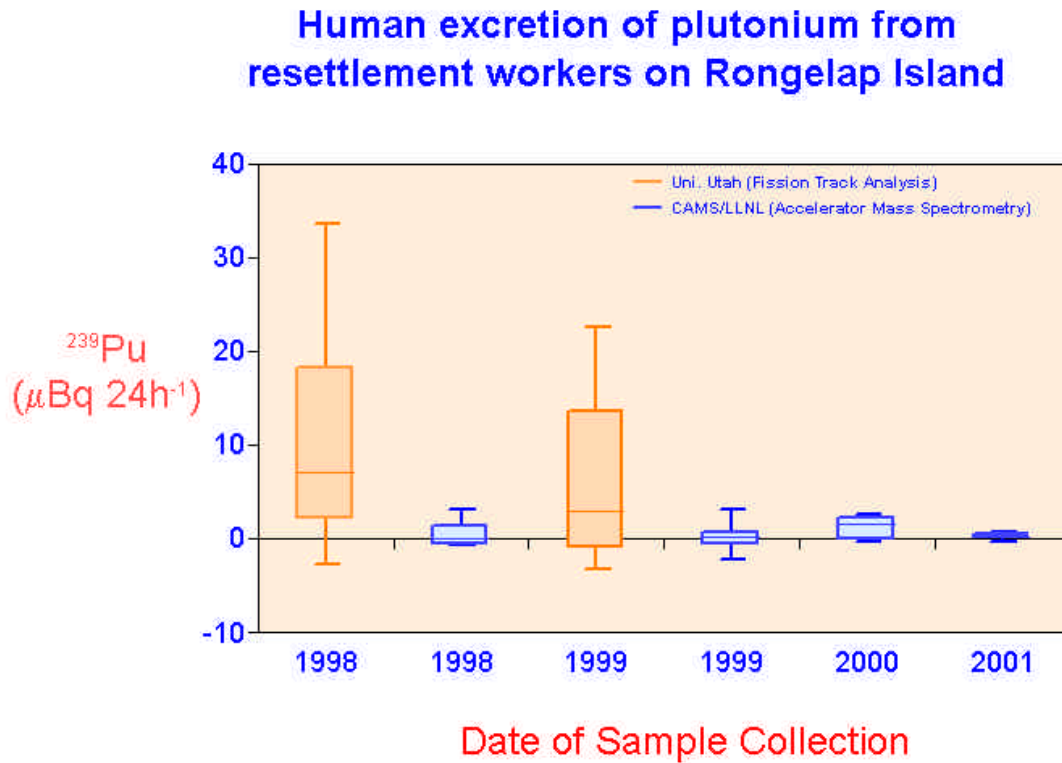
## PLUTONIUM URINOLYSIS MONITORING, CONTINUED



The Center for Accelerator Mass Spectrometry (CAMS) at the Lawrence Livermore National Laboratory is a state-of-the-art facility providing a low-level detection capability for measurement of plutonium in bioassay samples. The accelerator based measurement technology is sensitive enough to measure doses of less than 0.02 mrem per year. At this level of detection we are able to assess exposures to plutonium that are 7000 times lower than what people unavoidable receive from exposure to natural sources of radiation in the environment.

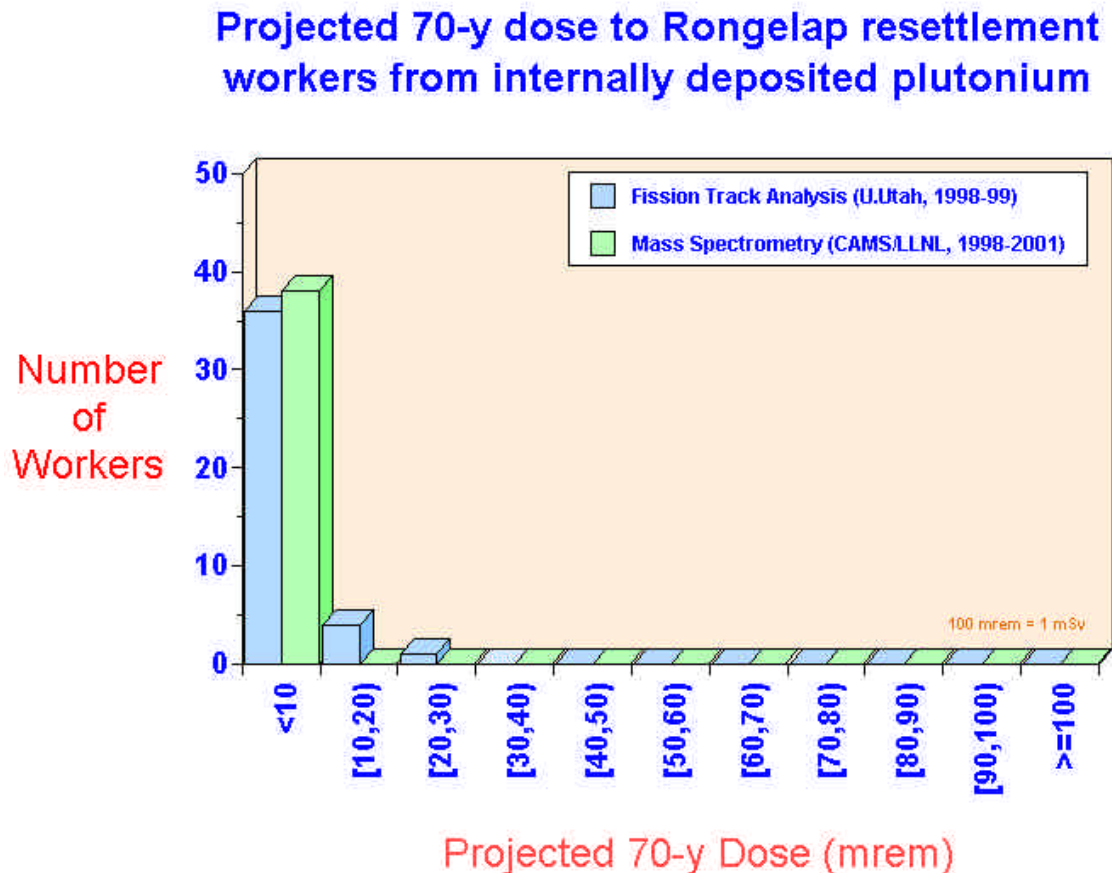
The advanced technology used at Livermore in support the Rongelap urinalysis program far exceeds all requirements of occupational monitoring programs in the United States.

## WHAT DO THE RESULTS OF PLUTONIUM URINALYSIS SHOW?



Rate of urinary excretion of plutonium by Rongelap resettlement workers. The vertical axis shows the measurement data expressed in units of microBecquerel ( $\mu\text{Bq}$ ) per day. The horizontal axis shows the date of collection.

## PROJECTED 70-Y DOSE TO RONGELAP RESETTLEMENT WORKERS FROM INTERNALLY DEPOSITED PLUTONIUM (1999-2002).

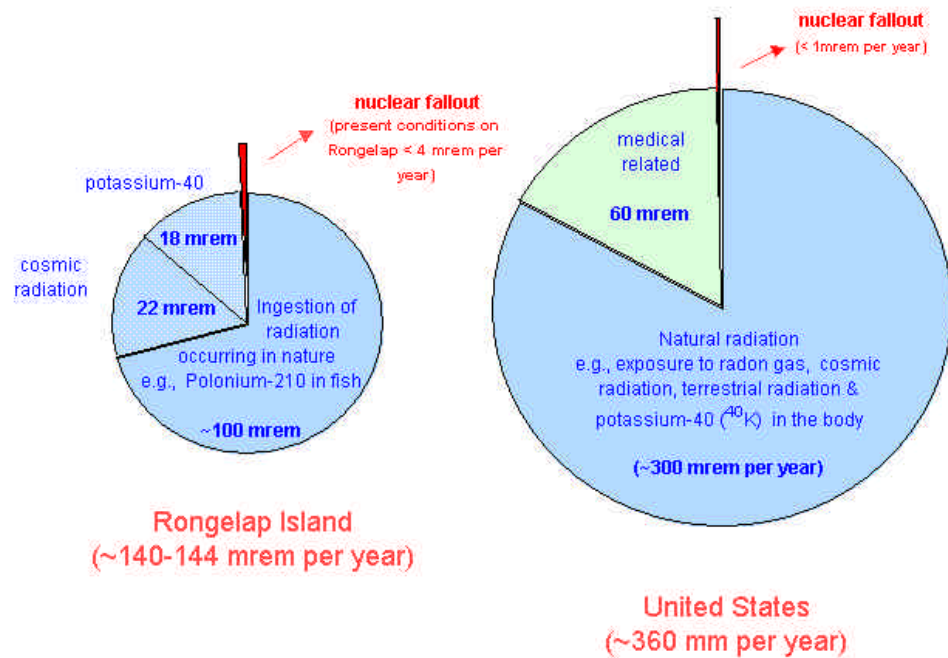


The amount of plutonium detected in bioassay samples collected from nearly 100 individuals during 1999–2002 fell at or below the critical level of detection for the measurements. This would normally negate the need to report a dose; rather, we would assume the dose from plutonium was zero. For completeness, dose estimates have been included in our reporting. The projected lifetime dose from exposure to plutonium for all individuals tested on Rongelap is below 10 mrem over 70 years.

The estimated doses pose no measurable or discernable health risk.

# COMPARISON OF RADIATION DOSES IN THE MARSHALL ISLANDS AND UNITED STATES

## Exposure to natural and man-made sources of radiation



The dose that people receive from ingestion of cesium-137 in locally grown foods needs to be put in perspective. For example, potassium is an essential element for life but happens to be partly radioactive. Naturally occurring potassium-40 in the body contributes about 14 mrem to our annual internal dose in the same manner as cesium-137. A standard medical X-ray contributes a dose of about 6 mrem.

The total natural background dose in the Marshall Islands is around 140 mrem per year and is derived largely from eating naturally occurring polonium-210 in fresh fish. People in the United States receive a much higher natural radiation dose of around 300 mrem per year. The overall health risk from radiation exposure is determined from the sum of the natural and manmade doses. The average estimated internal dose from cesium-137 measured in the body of Rongelap resettlement workers is much less than 1% of their total natural background dose.

The internal dose from cesium-137 is also well below the recommended cleanup standard of 15 mrem per year adopted by the Republic of the Marshall Islands. International agencies have adopted a much less stringent standard of 100 mrem per year above background for protection of members of the public.



## CONCLUSIONS

The WBC data acquired on Rongelap Island over the past 2 years clearly shows that resettlement workers received a negligible radiation dose from ingestion of Cesium-137 in locally grown foods. The data also demonstrate that the potential associated health risks were very low. This is equally true when addressing the issue of individual high-end doses to workers. Based on the dietary habits and life styles of workers, and data collected from environmental monitoring and whole body counting program, it appears that the Rongelap resettlement program will easily achieve the cleanup standard of 15 mrem per year adopted by the Republic of the Marshall Islands. At the same time, the Rongelap leadership has shown a great deal of initiative by establishing a WBC facility on island to provide confirmatory measurements. The WBC system will offer an unprecedented level of radiation monitoring protection for the people of Rongelap until it is clearly demonstrated that radiation surveillance measures can be relaxed. The value of this type of radiation protection monitoring program lies in the fact that the WBC data provides an absolute measure of the full range of exposures in the local population. Information about individual exposure and potential health risks can be estimated from direct measurements rather than rely on assumptions based on a range of different exposure scenarios. Residents who receive a whole body count that shows the presence of Cesium-137 can now make an informed decision about their eating habits and/or life style based on what is considered a 'safe' or acceptable health risk. The Marshall Islands Government has adopted a very stringent cleanup dose standard of 15 mrem per year as an acceptable level of risk – and as the community returns to their native island, individuals can be reassured that radiation related health risks remain at or below these standards while enjoying the benefits of a more desirable life style.



# GLOSSARY OF TERMS

## **Becquerel (Bq)**

A Becquerel (abbreviated as Bq) is the International System (SI) unit for activity of a radioactive material. One Bq of radioactive materials is the amount of material in which one atom is transformed or undergoes one decay every second.

## **Calibration**

The process of adjusting the response of an instrument to give accurate readings.

## **Critical Level**

The amount or number of counts at or above which a decision is made that a radioactive material is definitely present.

## **Dose Equivalent**

The dose equivalent is the dose taking into account the biological effectiveness of radiation to cause damage.

## **High End Health Risk**

Relates to the maximally exposed individual in a population

## **Internal Dose or Exposure**

That portion of the dose equivalent received from radiation sources inside the human body.

## **Individual**

Any human being

## **Isotope**

An atom of the same element having slightly different atomic mass. We identify different isotopes by appending a number relating the mass of the isotope to the name of the element. An example is cesium-137 which is often abbreviated as  $^{137}\text{Cs}$  where the chemical symbol for cesium is Cs.

## **Quality Assurance**

Actions taken to control a measurement process to ensure that they meet applicable standards.

## **Radiation Dose**

Radiation dose is a generic term used to estimate radiation induced health risks and is usually expressed in units of mrem per year.

## **Radioactivity**

A natural or spontaneous process by which unstable atoms of an element emit energy and/or particles, and change (or decay) to a different element or different isotopes of the same element.

# Appendix 1

## Individual Annual Dose Report

All volunteers receive an individual annual dose report during each year of participation in the whole body counting or plutonium urinalysis programs.

A sample of a dose report is shown below.

The report shows the annual dose the individual received during the year. This dose can be compared with a natural background dose of 140 mrem in the Marshall Islands (received by people in the Marshall Islands). The report also includes a copy of all verified measurement data used to calculate the dose.

### Sample copy only



Lawrence Livermore National Laboratory  
HEALTH & ECOLOGICAL  
ASSESSMENT DIVISION

October 21, 2003  
Personal ID# <PersonalID>

TO: <Participant Name>  
FROM: Dr. Terry Hanson  
Marshall Islands Program Leader  
Lawrence Livermore National Laboratory  
SUBJECT: Individual Radiation Monitoring Report

Dear participant,

I am pleased to enclose a copy of your individual radiation monitoring dose report for the period through 31 December 2003 (see enclosed).

The Department of Energy, in cooperation with local technicians have provided routine monitoring of your internal dose (H<sub>int</sub>) from ingestion of natural U-235 by Whole Body Counting (WBC). These data have then been converted into a single annual internal dose as shown below. We have also collected urine samples from workers to monitor exposure to plutonium (in air) in the air that you breathe. Where both measurements are available the annual internal dose shown is the sum of the two dose estimates.

Your estimated annual internal dose for year 2003 was <Total Dose, 2003> millirem (mrem).

This is significantly lower than the dose limit in the United States of 100 mrem/year for members of the general public, and is less than the 17 mrem/year adopted by the Republic of the Marshall Islands.

Consequently, under your present living/working conditions you appear to be receiving adequate radiation protection.

Thank you for your participation.

### Individual Radiation Monitoring Report

Personal ID	Last Name	First Name	Address
0000000	Doe	John	Lawrence Livermore National Laboratory P.O. Box 808 Livermore CA 94539 United States of America

### Internal Dose Report

Year	Cesium-137		Plutonium-239		Plutonium-240	
	Annual Dose	CEDE*	Annual Dose	CEDE*	Annual Dose	CEDE*
	mrem	mrem	mrem	mrem	mrem	mrem
2001	15.0	21.0	0.00	0.0	0.00	0.0

\*CEDE=Committed Effective Dose Equivalent over 70 years.

The amount of radiation a person receives is called the "effective dose equivalent" and is measured in thousandths of a rem (called the millirem) and is abbreviated or shortened to mrem. Your internal dose from ingestion of cesium-137 and inhalation of plutonium-239 has been converted into a single internal annual dose and a CEDE as shown above. This compares with an estimated Marshall Islands background dose of 140 mrem/year. The international scientific community has adopted the use of a different term for millirem called the millisievert (mSv). A millirem is the same as one-hundredth of a mSv.

### Cesium-137 Internal Monitoring Data

#### Whole Body Counting (WBC)

Date of Count	Nuclide	Unit	Activity	Uncertainty Range	
				Maximum	Minimum
5/21/01	Cesium-137	kBq	4.20	4.62	3.78
6/28/01	Cesium-137	kBq	4.20	4.62	3.78
9/10/01	Cesium-137	kBq	4.20	4.62	3.78
10/12/01	Cesium-137	kBq	4.20	4.62	3.78
12/12/01	Cesium-137	kBq	4.20	4.62	3.78

### Plutonium Internal Monitoring Data

#### Plutonium Urinalysis (Pu in urine)

Date of Collection	Nuclide	Unit	Activity	Uncertainty Range	
				Maximum	Minimum
8/1/01	Plutonium-239	uBq/24 h void	0.0	0.0	0.0
8/1/01	Plutonium-240	uBq/24 h void	0.0	0.0	0.0

Plutonium analyses were performed by the Center for Mass Spectrometry at the Lawrence Livermore National Laboratory using the new state-of-the-art measurement technology Accelerator Mass Spectrometry (AMS). Accelerator mass spectrometry is about 100 times more sensitive compared with classical bioassay monitoring techniques. The results show that levels of plutonium in your urine are within the normal worldwide background range.